There is no mass squared term in neutrino electric charge

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Abstract

We claim that the neutrino mass squared term cannot appear in the expansion of the neutrino electric charge over the neutrino mass parameter at the one-loop level of the standard model supplied with SU(2)-singlet right-handed neutrino.

Neutrino electromagnetic properties is an interesting and longstanding problem. The most important static electromagnetic characteristics of neutrino are the electric charge and magnetic moment. It is obvious that a massless particle can possess neither electric charge nor magnetic moment. However, in the case of non-zero mass, due to the radiative corrections the neutrino static electromagnetic moments can have non-vanishing values.

Recently the massive neutrino electric charge Q_ν was estimated in [1] as follows,

$$Q_\nu = -\frac{3eG_F m_\nu^2}{4\pi^2\sqrt{2}}, \quad e = -|e|, \tag{1}$$

so it was supposed that the non-vanishing neutrino electric charge could be proportional to the neutrino mass squared.

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In this short note we argue that the estimation for the neutrino electric charge, given by eq.(1), is not correct. This statement is based on our investigations [2] of the massive neutrino electromagnetic form factors. In particular, we calculated the one-loop contributions to the massive neutrino electric charge and magnetic moment within the context of the standard model supplied with SU(2)-singlet right-handed neutrino in arbitrary R_ξ gauge. It is important for the present discussion that our recent studies [2] enables us to consider the dependence of the neutrino charge on the mass of neutrino. The neutrino electric charge can be represented as a series-expansion over the neutrino mass parameter $b = (m_\nu/M_W)^2$,

$$Q_\nu(a, b, \alpha) = Q_0(a, \alpha) + bQ_1(a, \alpha) + \mathcal{O}(b^2), \tag{2}$$

where m_ν, M_W, and m_e are the neutrino, W boson, and charged lepton masses, respectively, and α is the W boson gauge parameter. In [2] it was shown by the direct calculations that the both functions in eq. (2), $Q_0(a, \alpha)$ and $Q_1(a, \alpha)$, vanish for arbitrary values of a and α. Thus, at the one-loop level there are no mass squared contributions to the neutrino electric charge for any gauge.

Moreover, we also shown in our paper [2] that for a particular choice of the gauge fixing parameter $\alpha = 1$ (the 't Hooft-Feynman gauge), the neutrino electric charge is exactly zero,

$$Q_\nu(a, b, \alpha = 1) = 0, \tag{3}$$

for any values of the mass parameters a and b. It is obvious again that there is no room for the mass squared terms in the neutrino electric charge for arbitrary neutrino mass on the one-loop level.

In the paper [1] there is an attempt to establish the relation between the neutrino neutrality and masslessness on the basis of eq. (1) using the results of [3]. Indeed, it was shown in [3] that the neutrino electric charge is vanishing. However, in the study of the neutrino electric charge in [3] it was assumed just in the beginning of the calculations that the mass of neutrino is zero. Thus, contrary to the last claim of [1], the present limits on the neutrino mass and possible neutrino non-zero electric charge does not provide any reason to introduce a new structure for electromagnetic gauge invariance .

References

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